
Advanced Space
Transportation Program
Presentation to
Space Transportation Lead Center
Program Management Council
NASA
ASTP
March 2nd, 2000

ASTP Objectives

The overall ASTP objective is to provide the technologies to reduce risk for operational system developments while addressing future breakthrough technologies beyond the next generation.

- **ASTP will mature those technologies that will provide the greatest total safety improvement and cost savings over the life of a space transportation system. This will be accomplished through focused activities (mission and customer“pull”).**

- **ASTP will seek to advance technologies that increase performance margin, thus enabling missions that are currently not technically or economically feasible (technology “push”). These missions include safe, routine earth-to-orbit transportation (Spaceliners), rapid human and robotic transportation to the planets and nearby celestial bodies and interstellar missions.**

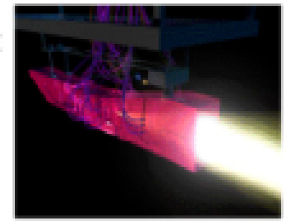
Earth-to-Orbit Goals, Objectives and Challenges

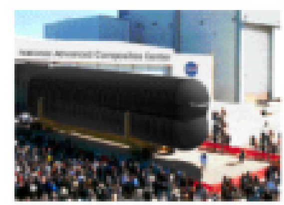
Goals

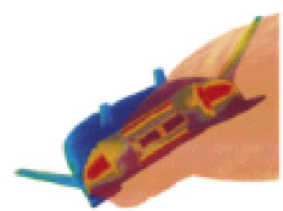
10x Cost Reduction & 100x Safety Increase by 2010

100x Cost Reduction & 10,000x Safety Increase by 2025

Technology Objective	Challenge
Increase System Performance margin	Increased Engine Thrust/Weight Increased Mission Specific Impulse Improve Mass Fraction Increased Range (Cross and Down)
Drive Down Operations Costs	Increased Margin Increased Reliability Increased Life Increased Vehicle Health/ State Knowledge Reduced Labor Reduced Processing Reduced Facilities/GSE Reduced Maintenance
Drive Down Manufacturing and Production Costs	Reduced Facilities Reduced Tooling Reduced Material Cost Reduced Labor
Drive Down Design, Development, Test and Evaluation Costs	Reduced Design Cycle Time Reduced Weight Reduced Complexity Increased Technology Readiness Level @ Insertion







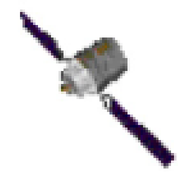
In-Space Goals, Objectives and Challenges

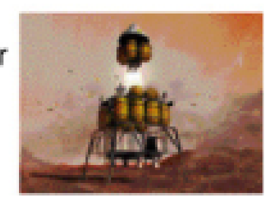
Goals

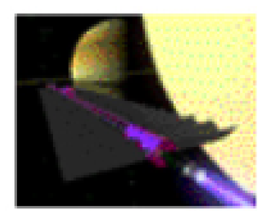
10x Cost Reduction and 2–3 Reduction in Mass and Travel Time

Enable Bold New Interstellar Missions by Reducing Travel Time 10–100x

Technology Objective	Challenge
Affordable Earth Orbital	Long Life, High Power Electric Propulsion; High Performance Chemical Systems; Advanced Cryogenic Engine; Reusable Transfer Vehicle Technologies
Fast Interplanetary Transfer	Longer Life, Lighter Weight Ion Engines; High Power Electric Propulsion; Light Solar Sails, Beamed Energy; Nuclear Options
Efficient Orbit Insertion/ Planetary Capture	Ultra-light Tanks, Feed Systems For Chemical Engines; Aerocapture Technologies; Milli-newton Thrusters For Precise Pointing
Efficient Ascent/Descent	Ultra-light Tanks, Feed Systems For Chemical Engines; In-situ Propellant Utilization; GN&C For Precision Landing
Enabling Interstellar	Concept Architecture Studies; Ultra-light Solar Sails, Ultra-high Power Laser; Fusion Energy; Matter/Anti-matter Annihilation







Three Tiered Technology Maturation Approach

CUSTOMER NEEDS

Trailblazer Class Demonstrators

- Integrated system technology flight demonstrators
- Responds to mission needs "pull"
- Verifies operability & programmatic viability
- May provide residual capability (science payloads)
- End users share in both decisions and cost

Flight When Required

future X

Pathfinder Class Demonstrators

- Narrow focus flight technology demonstrators
- Driven by technology
- Development similar to "Discovery" spacecraft series
- Less than ~ $100M each
- In test in less than ~ 3 years
- Allows for NASA and industry development

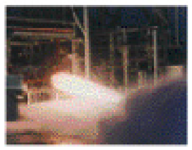
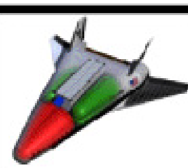
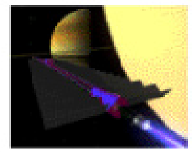
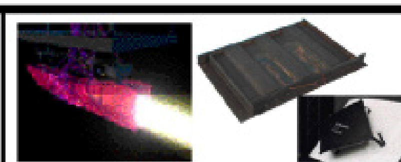
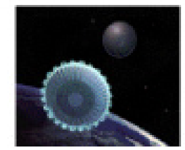
Focused

Aero-Space Base Technology

Cross-Cutting Technology Pipeline

Long Term Research

ASTP Organization is Driven By Goals

	Pillar 3					
						
Goal	Earth-to-Orbit	Earth-to-Orbit	In-Space	In-Space	Earth-to-Orbit	Earth-to-Orbit & In-Space
Investment Area	2nd Generation RLV		In-Space		Spaceliner 100 (3rd Generation RLV)	Space Transportation Research
Projects	Fastrac	RLV Focused	Upper Stages Space Transfer Technology	Interstellar Precursor	Propulsion IVHM Airframe Operations & Range Launch Vehicle	Breakthrough Propulsion Physics Advanced Propulsion Research

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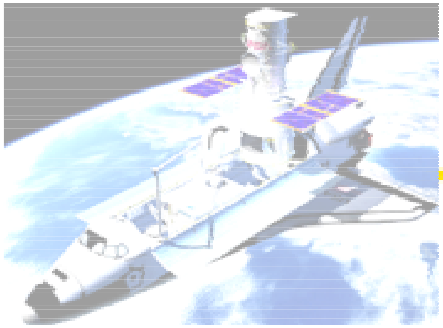
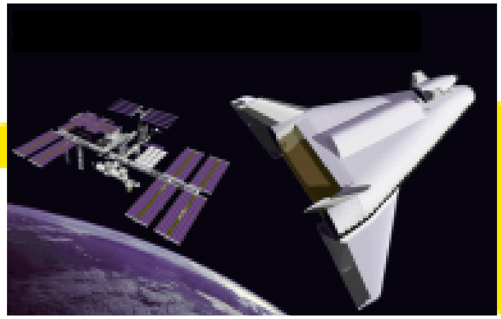
ASTP Earth-to-Orbit Investments Support Several Generations of RLV's



Today: Space Shuttle
1st Generation RLV

- Orbital Scientific Platform
- Satellite Retrieval and Repair
- Satellite Deployment



2010: 2nd Generation RLV

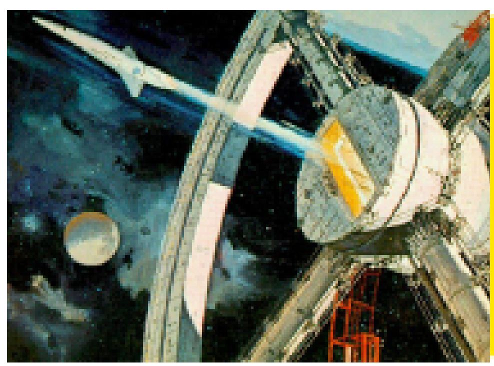
- Space Transportation
- Rendezvous, Docking, Crew Transfer
- Other on-orbit operations
- ISS Orbital Scientific Platform
- 10x Cheaper
- 100x Safer

2025: 3rd Generation RLV

- New Markets Enabled
- Multiple Platforms / Destinations
- 100x Cheaper
- 10,000x Safer

2040: 4th Generation RLV

- Routine Passenger Space Travel
- 1,000x Cheaper
- 20,000x Safer



Key Program Events of the Past Year

- **Late 1998:** Bantam Project Rescoped to Focus on Advanced Technologies
- **Spring 1999:** NASA Administrator Advocates Long Term Investment Strategy for Space Launch – Spaceliner 100
- **Summer 1999:** Enterprise Team Develops Spaceliner Investment Plan
- **Summer 1999:** Bantam Project Cancelled – Tasks Used to Initiate Spaceliner 100
- **Fall 1999:** $80M Congressional Plusup for Spaceliner 100
- **Fall 1999:** ISTP Combines 2nd and 3rd Generation Investments in One Integrated Plan
- **Late 1999:** ASTP is Reorganized and Incorporated into the Aero-Space Base to Foster Synergy with Aeronautics

Multi-Center Program Organization

Overview — **2000 PMC**

Advanced Space Transportation Program
Garry Lyles, Manager
Steve Cook, Deputy
Eric Hyde, *Technical Assistant*
Sherry Buschmann, *Assist. Mgr.-Prog. Integration*
Jenny Adams, *ESA*
Patti Brinkley, *MSA*

- **Business Manager** — Janet Crawford (MSFC)
- **Systems Analysis** — David Anderson (MSFC)
- **Systems Engineering** — Harlan Pratt (MSFC)
  - Nikhat Shahzad, *S&MA Engineer*

2nd Generation RLV Investment Area

- **RLV Focused Project** — Shayne Swint, *Manager (MSFC)*
  - Vacant, *Systems Engineer*
- **Fastrac Project** — Danny Davis, *Manager (MSFC)*
  - Wendy Cruit, *Assist. Manager*
  - Richard Sheppard, *Fastrac Systems Engineer*
  - B.J. Smith, *Fastrac Systems Engineer*

SpaceLiner 100 Investment Area

- **Propulsion Technology and Integration Project** — Uwe Hueter, *Manager. (MSFC)*
  - George Young, *Rocket Lead Engineer*
  - Vacant, *Rocket Systems Engineer*
  - Jim Turner, *Airbreathing Lead Engineer*
  - Craig McArthur, *Airbreathing Systems Engineer*
  - Catherine McLeod, *Airbreathing Systems Engineer*
- **Propulsion Research and Technology Project** — Harry Cikanek, *Acting Manager (GRC)*
- **Airframe Technology Project** — Joan Funk, *Manager (LaRC)*
- **Launch Technology Project** — Vacant, *Manager*
  - Vacant, *Systems Engineer*
- **Operations and Range Technology Project** — Warren Wiley, *Manager (KSC)*
  - Bruce Morris, *Assist Manager (KSC Rep.)*
- **Integrated Vehicle Health Mgmt. Project** — Charlie Simonds, *Manager (ARC)*
  - Bill Kahle, *Assist Manager (ARC Rep.)*

In-Space Investment Area

- **Upperstage Project** — Curtis McNeal, *Manager. (MSFC)*
- **Space Transfer Technology Project** — Leslie Curtis, *Manager (MSFC)*
  - Randy Bagget, *STEP Manager*
  - Melody Herrmann, *Tether Systems Engineer*
  - Judy Balance, ProSEDS *Assist Manager/Lead Engineer*
  - Kelly Looney, *ProSEDS Systems Engineer*
  - Tommy Harris, *ProSEDS Systems Engineer*
  - Rae Ann Meyer, *In-Space Lead Engineer*
- **Interstellar Precursor Project** — Les Johnson, *Manager (MSFC)*
  - Bill Pannell, *Interstellar Systems Engineer*
  - Saroj Patel, *Exploration Systems Engineer*

Space Transportation Research Investment Area

- **Adv. Prop. Research Project** — John Cole, *Manager (MSFC)*
  - Scott Jackson, *Research Sys. Engr.*
- **Breakthrough Prop. Physics Project** — Marc Millis, *Manager (GRC)*

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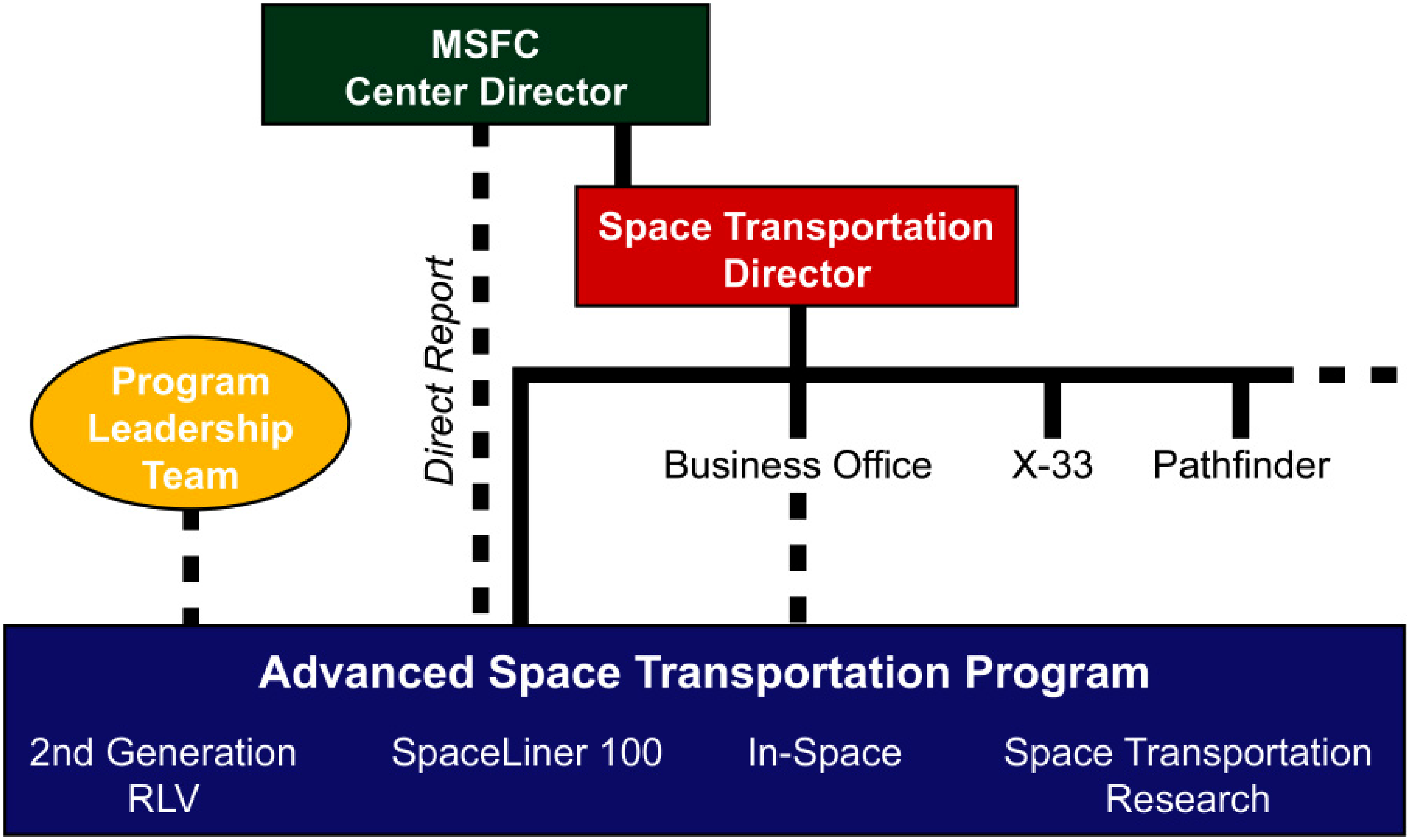
MSFC Organizational Structure



Dependencies and Reliances

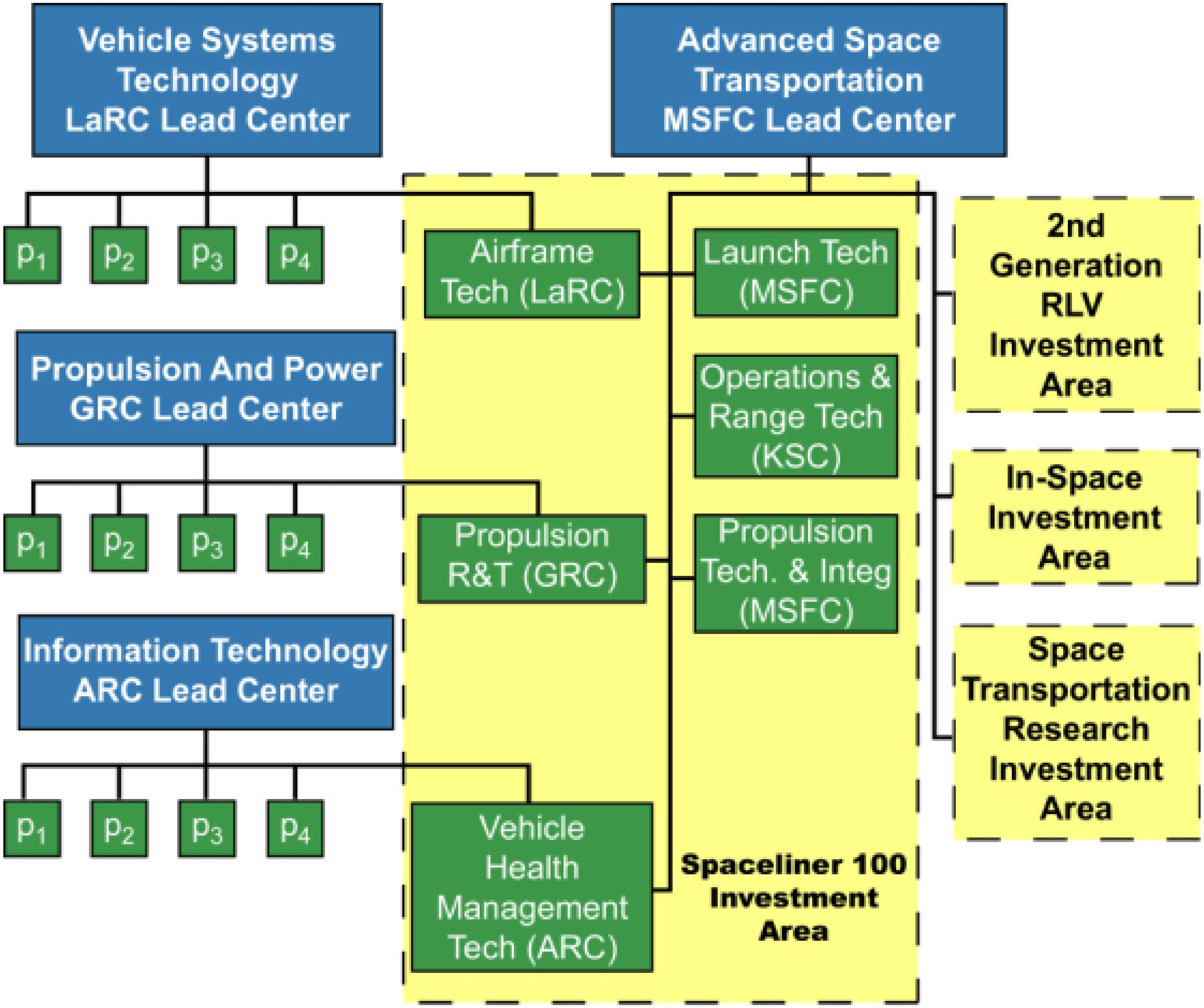
	ARC	DFRC	GRC	GSFC	JPL	JSC	KSC	LaRC	MSFC	SSC
Program Management									x	
Systems Engineering, Vehicle Design and Integration									x	
Systems Analysis (Intercenter Systems Analysis Team (ISAT))	x	x	x		x	x	x	x	x	x
Propulsion System Design & Integration									x	
- Advanced Propellants			x						x	
- Turbopump System Design & Integration									x	
- Turbomachinery Component R&T			x							
- Combustion Component R&T			x						x	
- On-board Storable Propellant Reaction Control Systems									x	
- In-space Cryo Fluid Management	x		x						x	
- In-situ Propellant Production					x				x	
- Rocket Engine Propulsion Systems									x	
- Combined Cycle Propulsion Systems									x	
- Combined Cycle Flowpath Performance / Turbine			x							
- Aero/Aerothermodynamics/Dual-Mode Ram/Scramjet								x		
- Aeropropulsion Systems			x							
- Micropropulsion			x		x					
- Non-chemical Propulsion Research			x		x				x	
- Advanced Deep Space Propulsion Concepts					x					
- Propulsion System Analysis									x	
Electric Propulsion Systems			x							
- On-board Electric Propulsion			x		x				x	
Rocket Propulsion System and Subsystem Testing										x
- Propulsion Test			x			x			x	

Dependencies and Reliances Cont'd

	ARC	DFRC	GRC	GSFC	JPL	JSC	KSC	LaRC	MSFC	SSC
Integrated Vehicle Health Management Architecture	x									
- Integrated Vehicle Health Management	x		x		x	x	x	x	x	
Avionics Systems Design & Integration									x	
- Advanced Instrumentation	x	x	x	x		x		x	x	
- Guidance Navigation and Control				x				x	x	
- Micro-electronics					x					
Power Systems			x							
- Power Sub-systems			x						x	
- Power Systems Distribution			x						x	
Structural and Mechanical Design & Integration									x	
- Propellant Tankage, Cryo Insulation and Feed Systems								x	x	
Advanced Manufacturing and Processes									x	
Materials Research								x		
- Materials Research	x		x		x	x	x	x	x	
Airframe Design								x		
- Metallic Thermal Protection Systems								x		
- Integrated Thermal Structures								x		
Thermal Protection Systems	x									
Crew and Passenger Systems						x				
- Crew Interfaces								x		
Payload and Launch Operations							x			
- Range Safety							x			
- Operations Technology		x					x			
Atmospheric Flight Operations		x								

OAT Aero-Space Base Programs Structure

Overview — 2000 PMC



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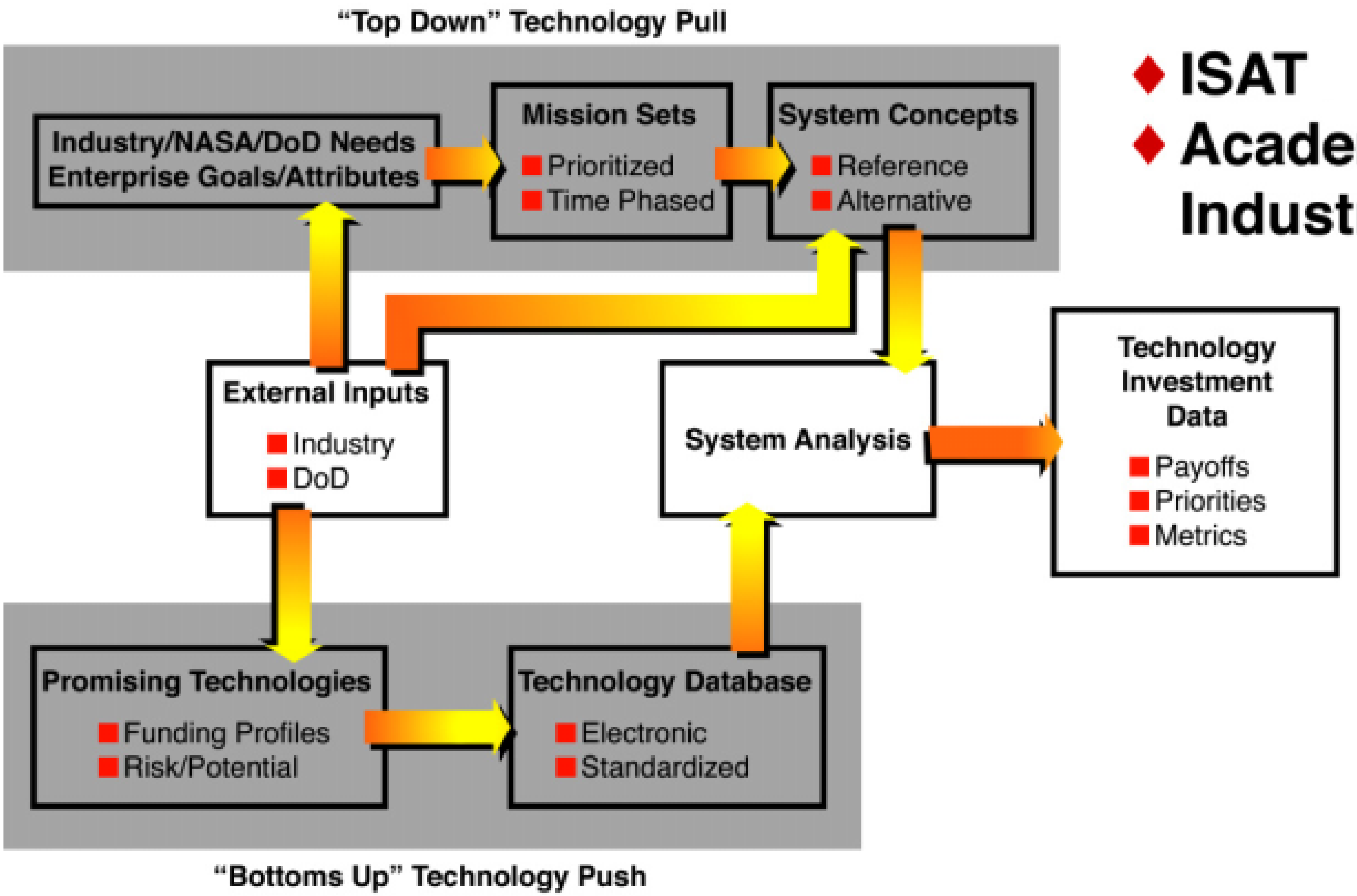
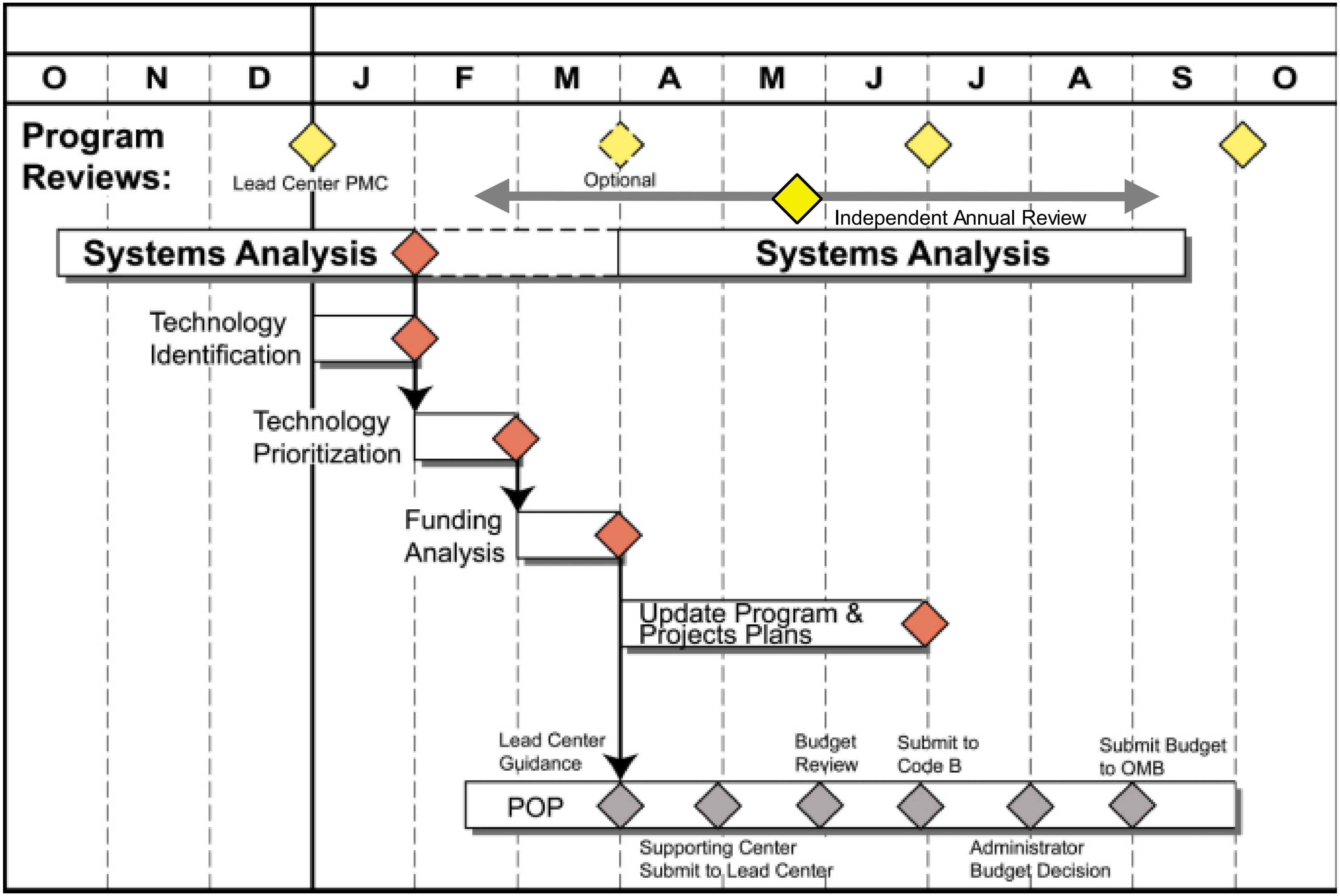
Systems Analysis Will Guide Future Investments



- ISAT
- Academia and Industry

Annual Planning Process

Overview — 2000 PMC



Program (Level 1) Milestone Status

Milestone	Date	Output	Outcome	Status
Complete NSTAR Mission Profile Testing	Sep-00	Complete NSTAR Mission Profile (100% design life) ground testing for Deep Space-1 (concurrent, identical firing of an NSTAR engine in a vacuum chamber with the actual firing sequence of the in-flight propulsion system).	Allows increased payload capability over chemical systems, reducing launch mass.	G
Complete 500-hour Test of 10-kW Hall Electric Thruster	Jun-00	500-hour demonstration of a 10-kW Hall thruster in ground testing	Allows increased payload capability over chemical systems, reducing launch mass	G
LOX Densifier verification testing and completion of hydrogen densifier build	Jun-00	Validate design, technology and operational characteristics of X-33 scale liquid oxygen propellant densifier, and prove readiness for use in experimental propulsion ground test or flight test program. Completion of Hydrogen densifier assembly	Data base for design and development of operational equipment for densification which when employed provides a 5-15% volume advantage which directly translates into reduced cost/increased performance.	G
Deliver Fastrac Engine to X–34	Jun-00	1st Fastrac engine certified for flight on the X–34	Significant reduction in the development cost of Earth-to-orbit propulsion	G
Complete fabrication of Metal Matrix Composite (MMC) & Polymer Matrix Composite (PMC) thrust cell chamber demonstration units	Aug-00	Delivery of multiple demonstration units, each fabricated with different composite structural jackets surrounding a new copper alloy liner.	Demonstrate successful fabrication of thrust cell chambers using new material systems that offer weight savings up to 40%.	G
Advanced TPS panel development, fabrication and test	Sep-00	Database of advanced TPS coatings and materials. Advanced TPS concept validated through ground test.	Advanced TPS is more robust and required significantly less maintenance than current ceramic tile and blanket TPS.	G
Composite Cryogenic Tank and Integrated Structures Demonstration	Jul-01	Validation of PMC cryogenic LH2 and LOX tanks to include validation of compatible materials systems and processes, fabrication and joining of large-scale articles, and demonstrated thermal-structural performance	Significant weight reduction for RLV cryotanks and primary structure can be quantified through actual test data.	G
Airbreathing Engine System Selection for first Flight Demonstrator	Sep-01	Engine preliminary designs reviews complete	Establish preferred airbreathing engine concept for FY 05 flight demonstrator which will directly	G
Flowpath Definition and Testing Completed for First Flight Demonstrator	Sep-01	Flowpath characterization complete	Used as criteria for airbreathing demonstrator engine selection which directly supports the long term objectives of Goal 9.	G

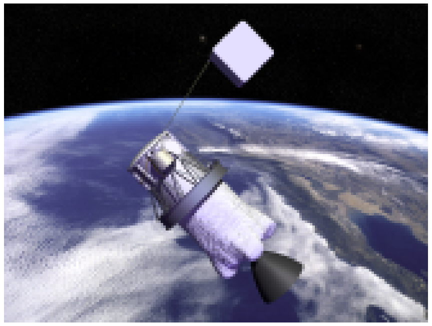
Risk Management Approach

- The Advanced Space Transportation Base R&T Program Office will assess risk on a continuous basis.
  - Each project manager will identify the principal technical risks and document these risks in the applicable project plan.
- The primary risk drivers for base technology development programs are:
  - (1) Critical enabling technologies encountering unexpected developmental difficulties
  - (2) Availability of financial and human resources
  - (3) Availability of critical facilities
- Risk beyond the scope of that which can be managed within an individual area will be addressed by
  - Reallocation of Resources
  - Descope or Deletion of Work Based on Systems Payoff

Scope of Today's PMC Review

- **All ASTP Managed Activities Except:**
  - **Fastrac Engine (Separate Independent Review Underway)**

  - **In-Space Pathfinder Program Experiments *Managed* by ASTP**
    - PROSEDS
    - Hall Thruster
    - Cryo Propellant Gauge



- **Remaining Activities are *Ground Based***